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# Summary Report on Motor Vehicle Emissions Inspection and Maintenance Programs for Non-Attainment Areas in Louisiana

TRW Environmental Engineering Div., Vienna, VA

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The report documents general information on motor vehicle inspection and maintenance (I/M) with respect to the metropolitan areas of New Orleans, Baton Rouge, and Shreveport. A background discussion of events leading to the need for an I/M program is provided. A general description of I/M is provided with respect to types of programs, the benefits of I/M, and information on implementation activities. Expected hydrocarbon emission reductions are included.

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# SUMMARY REPORT ON MOTOR VEHICLE EMISSIONS INSPECTION AND MAINTENANCE PROGRAM FOR NON-ATTAINMENT AREAS IN LOUISIANA

FEBRUARY 1979

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# SECTION 1

# INTRODUCTION

The purpose of this summary report is to provide general information about motor vehicle emissions inspection and maintenance (I/M) programs to the citizens of Louisiana. An I/M program is required by the 1977 Clean Air Act Amendments for those urban areas which are not expected to attain the ambient air quality standard for photochemical oxidants by December 31, 1982. In Louisiana, there are three urban areas which have been designated by the Environmental Protection Agency as non-attainment areas for photochemical oxidants. These areas are Shreveport, Baton Rouge, and New Orleans and include a total of seven parishes. In order to attain the photochemical oxidant standard in these areas, a program for reducing emissions of volatile organic compounds (VOC) will be implemented and consists primarily of the application of reasonably available control technology (RACT) to stationary sources. Significant emission reductions from motor vehicles will also be achieved by the Federal Motor Vehicle Emissions Control Program. The inspection and maintenance program has as its purpose a method to periodically monitor motor vehicle emissions to determine if they are meeting a prescribed standard and to require repair of the vehicle to the extent necessary to meet the emission limit.

This report discusses the background to the requirement for an I/M program, including the legislative authority, and presents a general description of I/M programs. Also included is a schedule for implementing an I/M program. The schedule is required by the Clean Air Act Amendments to be included in the revised State Implementation Plan (SIP) for attaining the photochemical oxidant standard.

# SECTION 2

# BACKGROUND

## 2.1 LEGISLATIVE AUTHORITY

Under the Clean Air Act Amendments of 1967, the National Air Pollution Control Administration was required to publish air quality criteria necessary for the protection of the public health and welfare. These criteria described the relationship between atmospheric concentrations of pollutants and their effects on human health and the environment. The 1970 amendments to the Clean Air Act required the Environmental Protection Agency (EPA) to promulgate National Ambient Air Quality Standards (NAAQS) for each air pollutant for which air quality criteria had previously been issued. Air quality standards were established for photochemical oxidants as well as sulfur dioxide, nitrogen dioxide, carbon monoxide, non-methane hydrocarbons, and total suspended particulates. Primary standards for these pollutants were set at a level to protect human health, while secondary standards were set at a level to protect plant and animal life, as well as prevent damage to materials.

After promulgation of the standards, each state and territory was required to submit to EPA a State Implementation Plan (SIP) which described the course of action that the state would adopt in order to attain the standards and the proposed attainment date. The latest date for attainment was set at July 1975. Since there were many areas in the country that were not attaining the standards, the 1977 amendments to the Clean Air Act specifically addressed those "non-attainment" areas in Section 172 of the amendments[1]. Each state was required by the amendments to submit a revised SIP by January 1, 1979, which showed attainment of the standards no later than December 31, 1982. For photochemical oxidants and carbon monoxide, an extension to 1987 may be granted if demonstration of attainment cannot be shown by 1982 with the application of reasonably available control technology (RACT). In order to obtain the extension to 1987, the revised SIP must contain a schedule for the implementation of a motor vehicle emission inspection and maintenance program. Under the requirements of the law, the EPA Administrator may impose sanctions if the states fail to comply with the requirements for standard attainment. These sanctions include disapproval of grants

for highway funds except for safety, mass transit or transportation improvement projects related to improvement for maintenance of air quality. If a state or local government is not implementing an SIP, they cannot receive any grants under the Clean Air Act. Federal agencies are required not to take any action including making any grant that does not conform to an approved SIP. In addition, no metropolitan planning agency shall give its approval to any project, program or plan which does not conform to an approved SIP. The Act also requires that priority be given for programs with air quality transportation consequences to the implementation of SIP's necessary to achieve and maintain air quality standards.

The ambient air quality standard for ozone was recently relaxed, therefore, an I/M program may not necessarily be needed in all three of the urban areas. If an I/M program is adopted in Louisiana, it will be used for the control of hydrocarbon emissions since these pollutants are a major contributor to the formation of ozone, the main component of photochemical oxidants. A beneficial effect on lowering carbon monoxide levels will also occur since many of the repairs or adjustments made to motor vehicles result in the reduction of both pollutants.

## 2.2 HEALTH EFFECTS OF PHOTOCHEMICAL OXIDANTS

The ambient air quality standard for photochemical oxidants was promulgated in 1971 as a result of the air quality criteria previously mentioned. The major component of photochemical oxidants is ozone ($O_3$) which forms as a result of the interaction between the emissions of volatile organic compounds (VOC), nitrogen oxides and sunlight. Hydrocarbon emissions from motor vehicles are among the volatile organic compounds contributing to oxidant formation.

Studies on health effects of exposure to both photochemical oxidants and ozone have shown evidence of eye, nose and throat irritation, at levels of 0.10 - 0.15 parts per million (ppm) of ozone in ambient air[2]. Respiratory impairment symptoms in healthy adults have been shown at levels of 0.37 ppm and higher. In experimental studies, ozone concentrations of 0.30 ppm have shown evidence of sore throat, chest pain, cough and headache[3].

In studies of animal exposure to ozone, an increased susceptibility to bacterial infection was noted following exposure of 0.10 ppm in

rodents. Biochemical alterations have been associated with ozone exposures over the range of 0.10 ppm - 1.0 ppm in animals, also. Atmospheric ozone has also shown damage to plant species, particularly tobacco and grape leaves, and pine trees.

## 2.3 NON-ATTAINMENT STATUS OF URBAN PARISHES

The 1977 Clean Air Act Amendments define a non-attainment area as an area which is shown by monitored data or which is calculated by air quality modeling (or other methods determined by the Administrator to be reliable) to exceed any national ambient air quality standard for such pollutant. Ambient air quality levels recorded in three urban areas in Louisiana during 1976 and 1977 indicate that ozone levels were in violation of the one-hour standard at that time of 0.08 ppm, and these areas were therefore declared non-attainment. These air quality levels are also in violation of the recently promulgated standard of 0.12 ppm for ozone. In developing a control strategy for reducing volatile organic compound emissions, it was found that emissions in 1982 could not be reduced to a level sufficient for attainment of the 0.08 ppm standard.

In determining the emission levels for 1977 and 1982, an inventory of volatile organic compound emissions in 1977 from all sources was compiled for each parish included in the non-attainment areas[4]. This inventory included rural as well as urban parishes, although only the urban parishes are required to demonstrate attainment of the standards. A summary of the VOC emissions from each of the seven parishes is shown in Table 2-1, which indicates that mobile sources contribute a significant amount of the emissions in each parish. In all parishes, highway vehicles comprise the largest percentage of the mobile source emissions. Since they are such a large contributor, they also provide a great potential for emission reduction. These reductions are achieved by the Federal Motor Vehicle Emissions Control Program, which is designed to reduce emissions of both hydrocarbons and carbon monoxide. In this program, new motor vehicles are required to meet a prescribed emission limit, and as they are introduced into the motor vehicle population and replace older vehicles, the total emissions decrease each year. The FMVCP is comprised of the three following elements:

TABLE 2-1. URBAN AREA VOC EMISSIONS SUMMARY (1977)

| PARISH | STATIONARY SOURCES | AREA SOURCES | MOBILE SOURCES | TOTAL |
|---|---|---|---|---|
| BOSSIER | 349.4 | 1,480.1 | 5,324.0 | 7,153.5 |
| CADDO | 2,173.3 | 7,295.8 | 16,583.1 | 26,052.2 |
| E. BATON ROUGE | 47,337.4 | 10,711.8 | 19,954.9 | 78,004.1 |
| W. BATON ROUGE | 3,823.4 | 1,283.9 | 3,302.8 | 8,410.1 |
| JEFFERSON | 22,256.2 | 6,430.2 | 13,848.3 | 42,534.8 |
| ORLEANS | 1,724.9 | 12,279.4 | 16,983.1 | 30,987.4 |
| ST. BERNARD | 13,364.3 | 1,699.7 | 3,556.5 | 18,620.5 |

a) Certification Program - Prototypes of new vehicles are certified to show that they are designed to meet Federal emission standards.

b) Selective Enforcement Auditing - Assembly line testing of new vehicles to assure that they are meeting emission standards when new.

c) Recall - Requirement that manufacturers recall vehicle types found during in-use surveillance to fail emission standards due to defects in design.

Although this program assists in introducing vehicles into the population that meet emission standards, many vehicles will not meet the standards once in use due to the following factors:

a) Vehicles may have disabled control systems due to deliberate modification or removal of the system to enhance vehicle performance.

b) Vehicles may be improperly maintained due to unfamiliarity of the owners or operators with emission control equipment maintenance requirements.

c) Not all vehicles are inspected at the assembly line; therefore, some may enter the market without meeting standards.

The emissions inspection and maintenance program supplements the FMVCP by assessing whether the vehicle meets the emission standards after it has been placed in use, and requiring repairs or adjustments where necessary.

In calculating the 1982 emissions, projections were made for each category of emissions included in the inventory and then compared with the required reductions, which are shown in Table 2-2. There are five cases presented on this table, one for each of the four levels of ozone transport with values presented for original transport and final transport, and the last case which is based on a straight rollback approach.

## 2.4 LOUISIANA MOTOR VEHICLE POPULATION AND VMT

The amount of additional emission reduction needed by the inspection and maintenance program will determine the stringency factor and the types of vehicles to be included in the program. The distribution of motor vehicles in Louisiana for 1976 is as follows:[5]

TABLE 2-2. URBAN AREA EMISSION REDUCTION REQUIREMENTS FROM 1977 LEVEL (%)[1]

| URBAN AREA | A.Q.DESIGN VALUE (PPM) | CASE 1 | CASE 2 | CASE 3 | CASE 4 | CASE 5 | ACHIEVABLE EMISSION[2] REDUCTIONS (%) IN 1982 |
|---|---|---|---|---|---|---|---|
| SHREVEPORT | 0.14 | 40.0 | 30.0 | 25.0 | 12.5 | 42.9 | 11.9 |
| BATON ROUGE | 0.19 | 60.0 | 53.3 | 53.8 | 46.2 | 57.9 | 36.2 |
| NEW ORLEANS | 0.15 | 45.5 | 36.4 | 33.3 | 22.2 | 46.7 | 36.8 |

[1] EXPLANATION OF CASES 1-5:

| | $T_o$ | $T_f$ |
|---|---|---|
| CASE 1 | 0.08 | 0.04 |
| CASE 2 | 0.08 | 0.02 |
| CASE 3 | 0.12 | 0.04 |
| CASE 4 | 0.12 | 0.02 |
| CASE 5 | STRAIGHT ROLLBACK | |

[2] BASED ON APPLICATION OF RACT AND FEDERAL MOTOR VEHICLE EMISSIONS CONTROL PROGRAM.

| | |
|---|---|
| Automobiles | 1,691,109 |
| Buses | 17,087 |
| Motorcycles | 57,832 |
| Trucks | 634,055 |

The average daily vehicle miles of travel (VMT) in each of the urban parishes for 1976 is presented below:(6)

| PARISH | VMT |
|---|---|
| Bossier | 1,259,687 |
| Caddo | 4,339,523 |
| E. Baton Rouge | 5,499,472 |
| W. Baton Rouge | 931,382 |
| Jefferson | 3,440,953 |
| Orleans | 4,550,034 |
| St. Bernard | 887,563 |

# SECTION 3

# GENERAL DESCRIPTION OF INSPECTION AND MAINTENANCE PROGRAMS

## 3.1 OBJECTIVES OF INSPECTION AND MAINTENANCE PROGRAMS

The objective of a vehicle inspection and maintenance program is to assure that in-use vehicles are meeting a prescribed emission standard designed to limit the amount of air pollutant emissions entering the atmosphere. A periodic inspection of motor vehicles within a certain area, with a follow-up adjustment or repair to the vehicle, is used to achieve this objective. As noted in the previous section, the emissions may deviate from the prescribed standard due to several factors. Since the failure of emission control equipment may not be readily noticed by the vehicle operator, an I/M program will identify those vehicles needing maintenance. Emissions from a poorly maintained vehicle are greater than from a well maintained vehicle; therefore, emission reductions are achieved through the proper maintenance of the vehicle. The overall goal of the I/M program is to increase the frequency and quality of the maintenance so that once the prescribed emission levels are achieved, they remain at that level.

It should be noted that not all vehicles subject to the inspection will require extensive repairs. Many vehicle owners and operators perform periodic maintenance such as tune-ups to their vehicles; therefore, there may not be any further maintenance requirements identified during the inspection. It is expected that there will be a greater interest in properly maintaining vehicles as a result of rising gasoline prices. It has been estimated that a fuel savings of approximately 5% can be achieved by vehicles repaired as a result of an I/M program.

## 3.2 BENEFITS OF INSPECTION AND MAINTENANCE PROGRAMS

### 3.2.1 Reduction of Exhaust Emissions

Since the goal of the inspection and maintenance program is to reduce the exhaust emissions entering the atmosphere, the benefit of the program can be assessed by the amount of emission reduction that can be achieved. Estimates of hydrocarbon emissions reductions were recently published in an EPA document, Mobile 1: Mobile Source Emissions Model[7],

and represent the most recent emission reduction credits. These credits are an updated version of the proposed rule, "Emission Reduction Achievable Through Inspection and Maintenance of Light-Duty Vehicles, Motorcycles, and Light and Heavy Duty Trucks"[8]. The EPA Office of Transportation and Land Use Policy is currently revising these credits and it is expected that they will be available in late 1979.

The impact of an inspection and maintenance program on the vehicle emissions can be evaluated by comparing the estimated emissions with and without an I/M program. The effectiveness of the program is directly related to the vehicle fleet included, the number of years the program is in operation, and the stringency factor which is the percentage of total vehicles tested in an I/M program in a given time period that fail the inspection and require maintenance and repair. Table 3-1 presents the estimated motor vehicle hydrocarbon emissions reductions achievable with an I/M program as compared to motor vehicle emissions without I/M. The following classes of vehicles included in these estimates were as follows:

Light duty vehicles (LDV) - automobiles

Light duty trucks 1 (LDT1) - trucks weighing 6000 pounds and less

Light duty trucks 2 (LDT2) - trucks weighing between 6001 pounds and 8500 pounds

Motorcycles (MC)

As shown on Table 3-1, emission reductions are higher when the program is started earlier, a higher stringency factor is used and vehicles other than just automobiles are included in the program.

There are several ongoing I/M programs in the United States which have been successful in reducing motor vehicle emissions. The nation's longest program is in New Jersey, which has reported an estimated 31% decrease in hydrocarbon emissions between 1979 and 1978[9]. This program is administered throughout the state. In Arizona, an I/M program is in effect in Phoenix and Tucson and have reported an estimated 41% reduction in hydrocarbon emissions from vehicles tested during 1977 when compared model year by model year to all vehicles tested in 1976[10]. In Portland, Oregon, an estimated 7% reduction in hydrocarbon emissions were achieved in the first inspection cycle[11].

TABLE 3-1. PERCENT REDUCTIONS IN MOTOR VEHICLE VOC EMISSIONS ACHIEVABLE WITH INSPECTION AND MAINTENANCE[a]

| I/M OPERATING PERIOD | STRINGENCY FACTOR (%) | PERCENT REDUCTION | |
|---|---|---|---|
| | | LDV[b] | LDV,LDT1,LDT2,MC[c] |
| 1981-1987 | 10 | 13.5 | 16.1 |
| | 20 | 15.5 | 18.6 |
| | 30 | 17.1 | 20.2 |
| | 40 | 18.1 | 22.3 |
| | 50 | 19.2 | 23.3 |
| 1982-1987 | 10 | 12.4 | 14.0 |
| | 20 | 15.0 | 17.1 |
| | 30 | 16.6 | 19.7 |
| | 40 | 17.6 | 21.2 |
| | 50 | 18.1 | 22.2 |
| 1983-1987 | 10 | 10.9 | 12.4 |
| | 20 | 12.9 | 15.0 |
| | 30 | 15.0 | 17.6 |
| | 40 | 16.1 | 19.2 |
| | 50 | 17.1 | 20.2 |

(a) Achievable VOC emission reductions over the 1987 level without I/M. Each I/M program includes mechanics training and model years 1972-1986.

(b) Inspection and maintenance program includes light duty vehicles only.

(c) Inspection and maintenance program includes light duty vehicles (LDV), light duty trucks 1 (LDT1), light duty trucks 2 (LDT2), and motorcycles (MC).

### 3.2.2 Gasoline Fuel Savings and Engine Performance

With the implementation of an inspection and maintenance program, there should be a positive effect on vehicle performance. This results from the fact that in order to reduce hydrocarbon emissions, efficient combustion of the fuel (gasoline) is necessary. In order to maintain efficient combustion, the factors influencing the burning of the fuel must be properly operating. According to EPA's Office of Air, Noise, and Radiation[12], a maximum of 5 percent savings in fuel results from the failed vehicles that are repaired. This means that the overall fuel savings is the stringency factor (failure rate) times the 5 percent savings in fuel for each failed vehicle.

## 3.3 TYPES OF INSPECTION TEST MODES AND INSTRUMENTATION

### 3.3.1 Test Modes

At present there are two general types of emission test modes: Idle mode and loaded mode test. The loaded mode test is further divided into the steady and transient loaded mode test. A general description of each of these test modes and the instrumentation needed for them are described below.

The idle mode test is the test of the exhaust emissions with the vehicle in a neutral gear and the engine operating at idle speed. Often, hydrocarbon (HC) and carbon monoxide (CO) levels are recorded at both a normal and high idle speed. The test at the normal idle speed is taken at the manufacturers' recommended idle speed measured in revolutions per minute (rpm), and then increased to 2,250 ($\pm$ 10 percent) rpm for the high idle speed test. The emission standards must be met at both levels.

The loaded mode test is the test of the exhaust emissions with the vehicle in a forward drive gear and operating at simulated driving conditions. The steady state loaded mode test measures emissions at high cruise, low cruise, and idle mode operating conditions. A chassis dynamometer loads the vehicle to simulate these driving conditions. Both the Clayton Key mode test and the Federal Three Mode test are acceptable steady state tests. These are described in Appendix A. Emissions are analyzed by the volumetric procedure, i.e., by a standard exhaust emission analyzer. The vehicle is operated in each mode until the emissions stabilize.

The transient loaded mode test collects a composite emission sample from a specified driving schedule. The composite sample is collected into a constant volume sample (CVS) unit for further analysis to determine pollutant concentration. Again, a chassis dynamometer loads the vehicle to simulate the desired driving schedule. However, for this test, the dynamometer must be capable of performing at variable inertial weights and road load settings. The driving schedule for the transient test simulates a portion of an urban driving cycle. Two acceptable cycles are the Composite New Jersey/New York test and the Federal Short Cycle Test. The Federal Short Cycle is a 9-mode CVS test of 125-second duration while the New Jersey/New York composite test is a 6-mode CVS test requiring 75 seconds[11]. Each of the test procedures is shown in Appendix A.

### 3.3.2 Advantages and Disadvantages of Different Test Modes

There are four options for the type of inspection and maintenance programs which can be used, and these are as follows:

1. Idle mode test conducted at state operated stations (centralized facility),
2. Idle mode test conducted at contractor operated stations (centralized facility),
3. Idle mode test conducted at private garages or service stations (decentralized facilities),
4. Loaded mode test conducted at contractor operated stations (centralized facility).

The following have been found to be major factors to be considered in choosing the appropriate test mode[13]:

- Effectiveness in identifying vehicles which exceed emission standards
- Engine diagnostic information provided by test
- Cost of testing equipment
- Relationship to organizational structure and other program factors
- Speed of test.

The advantages and disadvantages associated with idle versus loaded mode testing procedures are summarized in Table 3-2. With respect to overall effectiveness for hydrocarbon and carbon monoxide emissions, most research and field experience indicates that the idle mode can identify gross emitters equally well in comparison to the loaded mode procedure. The idle mode is also considered sufficient to identify HC and CO from catalyst equipped vehicles[14]. Idle mode test equipment costs less than loaded mode equipment. It has been found in a recent EPA study that loaded mode test equipment costs anywhere from 40 to 70 percent more than idle mode equipment[11]. From analyzing existing I/M programs it has been found that the idle mode test generally takes one or two minutes less than the loaded mode procedure, although in one state (Arizona) the loaded mode test takes the same time as the idle test in other states[13].

The loaded mode test simulates actual driving conditions, therefore it generally provides more in-depth diagnostic information. A California study found that the repair industry could not effectively make use of the more complicated diagnostic data which the loaded mode test produces.

The loaded mode test to date has only been used in centralized (contractor or state run) facilities. This is because the test equipment for a loaded mode test is too expensive for a decentralized (private garages) program. It may be possible to conduct the loaded mode test procedure at private garages if the state could subsidize or lease the more expensive equipment to the participating garages[13].

Since both state and private contractor operated stations are being considered in this study, the advantages of each are summarized in Table 3-3.

### 3.3.3 Instrumentation

The instrumentation required for I/M depends upon the type of test mode used. The gas analyzer measures the quantities of pollutants (HC, CO and $NO_x$) in the exhaust gases of a highway motor vehicle. Most exhaust gas analyzers are equipped to measure both hydrocarbons (HC) and carbon monoxide (CO) emission levels. These analyzers vary in complexity from simple meters displaying the pollutant concentration to digital

TABLE 3-2. IDLE VERSUS LOADED MODE TESTING ADVANTAGES AND DISADVANTAGES

| | ADVANTAGES | DISADVANTAGES |
|---|---|---|
| Idle Mode | 1. Can identify HC and CO gross emitters as well as loaded mode.<br>2. Can be easily duplicated at repair garage.<br>3. Equipment less costly.<br>4. Can be readily added to safety inspection program.<br>5. Takes less time. | 1. Cannot identify ($NO_x$ emission) with sufficient reliability.<br>2. Cannot simulate real driving conditions.<br>3. Diagnostic information generally less comprehensive.<br>4. Poor correlation with Federal Test Procedure. |
| Loaded Mode | 1. Can identify $NO_x$ emissions.<br>2. Simulates driving conditions.<br>3. Correlates with Federal Test Procedure | 1. Chassis dynamometer required.<br>2. Equipment less portable.<br>3. Equipment costs more.<br>4. Test cannot be duplicated in most repair garages. |

SOURCE: Midurski, Theodore P. and Ramsay, David. Evaluation of Motor Vehicle Emissions Inspection and Maintenance Programs in Ohio, Technical Memorandum No. 3--Test Mode (Idle, Loaded), GCA Corporation, GCA/Technology Division, April, 1978.

TABLE 3-3. ORGANIZATIONAL STRUCTURE: ADVANTAGES AND DISADVANTAGES[a]

| | Advantages | Disadvantages |
|---|---|---|
| Public Centralized | Consumer Protection:<br>1. Inspection separate from repair: no conflict of interest.<br>2. Independent basis for judging the performance of the service industry.<br>3. Monitoring of instruments' and inspectors' performance facilitated, thereby reducing testing variability.<br>Costs:<br>1. Lower (inspection) labor costs, thus generally lower recurring costs.<br>2. More efficient use of equipment.<br>Information:<br>1. Data collection facilitated.<br>2. Loaded mode testing possible. | Consumer Convenience:<br>1. Fewer inspection facilities, thus an increased probability of longer travel and wait times.<br>Cost:<br>1. Start-up requires large public capital outlay.<br>2. All program costs borne by public sector.<br>3. Risk of increasing long-term fixed costs to government due to increase in number of potential retirement/ pension beneficiaries. |
| Private Centralized | Consumer Protection Information: Same as public centralized<br>Cost: Same as public centralized, plus<br>1. All program costs borne by private sector except those associated with administrative oversight.<br>2. No risks of increasing long-term fixed governmental costs.<br>3. Permits use of corporate tax structure to reduce burden of start-up capital expenditures. | Consumer Convenience: Same as public centralized.<br>Consumer Protection:<br>1. Possible adverse public reaction to corporation earning profits from "captive market." |
| Private Decentralized | Consumer Convenience:<br>1. Greater number of facilities increases probability of minimizing travel and wait times.<br>2. Possibility for one-stop inspection/ maintenance.<br>Cost:<br>1. Lower start-up costs.<br>2. All program costs borne by private sector except administration and monitoring. | Consumer Protection:<br>1. Inspection not separate from repairs presents potential for conflict of interest and reduction of program effectiveness.<br>2. No independent basis for judging performance of service industry.<br>3. Effective monitoring of inspectors and instruments is more difficult.<br>Cost:<br>1. Higher administrative costs to manage and oversee large number of garages; higher labor costs; hence, higher recurring costs.<br>2. Less efficient use of equipment.<br>3. Inspector training involves greater numbers and is therefore more costly.<br>Information:<br>1. Uniform and detailed data collection is more difficult.<br>2. Loaded mode testing is improbable if not impossible. |

[a]From Bentz, E. J., Jr. Inspection/Maintenance Cost-Effectiveness and Feasibility of Implementation. U. S. Environmental Protection Agency, Washington, D. C., May 1977.

readout and printing capabilities, and finally having the potential for computer hookup for further data handling and analysis.

A chassis dynamometer is required, in addition to an emission analyzer if a loaded mode test is performed. The dynamometer consists of two rollers, upon which a vehicle's driving wheels are placed. The car can then be placed in gear and the rear wheels (front wheels if front wheel drive) driven on the rollers while the vehicle stands in place. Adjustable heavy inertial weights are attached to the rollers to resist changes in speed, thus simulating the weight of the vehicle. Also, a power absorption unit is usually attached to the rollers to resist their rotation and thus simulate wind and other resistances to the motion of a vehicle. With a chassis dynamometer it is possible to fully simulate the engine behavior for a vehicle on the road while the vehicle stands in place[15].

## 3.4 FAILURE RATE AND EXPECTED REPAIR COSTS

### 3.4.1 Failure Rates

The terms failure rate and stringency factor are synonymous. They represent the estimated fraction of the vehicle population whose emissions would exceed emission standards for hydrocarbons in order to achieve a desired emission reduction. The motor vehicle emission standards are set according to the failure rate required.

In summary, the failure rates needed for Louisiana's non-attainment areas to meet the minimum inspection and maintenance requirement (25 percent reduction in LDV exhaust emissions) are presented in Table 3-4.

### 3.4.2 Expected Repair Costs

The repair costs that a resident of Louisiana could expect to incur should range between $20 and $30. This was based on repair costs reported by I/M programs in other states[11]. A study of four I/M programs showed the overall average cost of repairs to be approximately $27.00, though well over half of these repairs fell under this figure. Table 3-5 gives detailed repair cost information from I/M programs in New Jersey, Oregon and Arizona.

Motor vehicle emissions are a result of the overall mechanics of an internal combustion engine. A change in operation of many vehicle

TABLE 3-4. MINIMUM FAILURE RATE (STRINGENCY FACTORS) REQUIREMENTS OF LDV I/M PROGRAM [a]

| I/M BEGINS (year) | STRINGENCY FACTOR | LDV EXHAUST EMISSION FACTOR[b] (Gms/Mile) |
|---|---|---|
| 1981 | 0.10 | 0.794 |
| 1982 | 0.20 | 0.769 |
| 1983 | 0.30 | 0.769 |

[a] These are for different I/M starting dates (depending on legislative action) and includes mechanics training and model years 1972-1986.

[b] Required LDV exhaust emission factor (based on minimum requirement of I/M to reduce LDV exhaust emissions by 25%) is 0.794 gms/mile.

systems and components could adversely affect a change in emissions. Table 3-6 lists the most common of these systems and components, their mode of operation causing the change in emissions, and the resultant effect on carbon monoxide and hydrocarbon emissions. Table 3-7 lists the major causes of exhaust emissions and Table 3-8 gives the distribution of the types of repair as reported by the Portland, Oregon, I/M program[11]. As can be seen from these tables, most repairs focus on carburetor and ignition system malfunctions.

## 3.5 IMPLEMENTATION OF I/M PROGRAMS

### 3.5.1 Public and Private Facilities

There are three main organizational options for conducting inspection and maintenance programs. They are the following:

1. Public: centralized test facilities operated by state, city and local government.
2. Private: (i) centralized facilities operated by a private contractor to a government, and

TABLE 3-5. REPAIR COST SUMMARY FOR EXISTING I/M PROGRAMS

| New Jersey | | Oregon | |
|---|---|---|---|
| Less than $10 | 29.7% | No cost | 27% |
| $10 to $25 | 26.4% | Less than $10 | 37% |
| $25 to $50 | 22.1% | $10 to $30 | 18% |
| $50 to $100 | 16.1% | $30 to $50 | 8% |
| More than $100 | 5.6% | $50 to $75 | 5% |
| | | More than $100 | 2% |
| N = 16,000<br>Avg. repair cost = $32.40<br>Median: 50% of repairs cost less than $20<br>65% of repairs cost less than average | | N = 1,400 (primarily newer cars)<br>Avg. repair cost =$16.00<br>Median: 50% or repairs cost less than $8<br>71% of repairs cost less than average | |

| Arizona | |
|---|---|
| Less than $5 | 27% |
| $5 to $10 | 17% |
| $10 to $25 | 24% |
| $25 to $50 | 20% |
| $50 to $100 | 10% |
| More than $100 | 2% |
| N = 2,000<br>Avg. repair cost = $23.40<br>Median: 50% of repairs cost less than $15<br>64% of repairs cost less than average | |

SOURCE: U. S. EPA, Information Document on Automobile Emissions Inspection and Maintenance Programs, EPA-400/2-78-001, February 1978

TABLE 3-6. EFFECT OF ENGINE COMPONENT OPERATION ON EMISSIONS

| COMPONENT | CHANGE IN EMISSIONS | |
|---|---|---|
| | CARBON MONOXIDE | HYDROCARBON |
| Decreased air-fuel ratio | Increase | Increase |
| Decreased engine idle speed | Increase | Increase |
| Restricted PCV valve | Increase | Increase |
| Restricted air filter | Increase | Increase |
| Choke malfunctions | Increase | Increase |
| Carburetor malfunctions | Large increase | Increase |
| Ignition system malfunctions | | Large increase |
| Advanced spark timing | | Decrease |
| Stuck heat riser valve | Increase | |
| Exhaust valve leak | | Increase |
| Intake manifold leaks | Increase | Increase |
| Emission control device malfunction | Increase | Increase |
| Catalytic converter breakdown | Large increase | Large increase |

SOURCE: U. S. EPA, Information Document on Automobile Emissions Inspection and Maintenance Programs, EPA-400/2-78-001, February 1978.

TABLE 3-7. MAJOR CAUSES OF EXHAUST EMISSIONS

Major causes of high carbon monoxide emissions are:

- Carburetor out of adjustment
- Air-fuel mixture imbalances
- Malfunction of emission control devices

Major causes of high hydrocarbon emissions are:

- Improper timing
- Ignition system malfunctions
- Malfunction of emission control devices

TABLE 3-8. TYPES OF REPAIRS REQUIRED*

| REPAIR TYPE | PERCENT UNDERGOING REPAIR |
|---|---|
| Carburetor adjustment | 78 |
| Tune-up | 14 |
| Engine overhaul | 1 |
| Valves | 1 |
| Other | 6 |

*Reported by Portland, Oregon, I/M program.

SOURCE: U. S. EPA, Information Document on Automobile Emissions Inspection and Maintenance Programs, EPA-400/2-78-001, February, 1978.

(ii) decentralized facilities operated by private automobile service garages, certified or licensed by a government.

In addition to the above, there is a fourth option that is possible. It is a combination of public and private facilities. For example, a privately operated decentralized facility may also include one or several state operated central facilities as retesting sites for failed vehicles or as a measure of quality control[8].

A detailed examinaticn of the advantages and disadvantages of each option were discussed in Section 3.3. The advantages of both public and private facilities in summary are: (i) the private garage approach provides the greatest convenience to the public, and since inspection and maintenance can be accomplished with one stop, indirect costs to the consumer are minimized; (ii) government operated central facilities are high capacity and the economy of constructing multilane testing centers can result in lower inspection costs, (iii) a central facility lends itself to simplified data handling and greater quality control, and (iv) a central facility constructed and operated by a private contractor minimizes the initial capital investment by the state, as in Arizona which has the longest ongoing contractor operated program.

### 3.5.2 Functions of Other Agencies

Since the planning and implementation of an I/M program can be very complex and include several varying functions, it is unlikely that any one agency would have the resources necessary for the implementation of the program. For example, some of the tasks involved in the I/M program include equipment procurement, installation and acceptance, vehicle inspection, enforcement of rules and regulations, training of personnel, consumer protection, and analysis of monitored data. Since several agencies may be involved, a close interagency relationship is a key element to a successful program.

A major factor in determining which agencies are involved in implementing an I/M program is the legislation which authorizes the program. If only one agency is given total responsibility, then that agency must

obtain cooperation from other agencies as necessary for performing the tasks mentioned above. In the State of Louisiana, the Louisiana Air Control Commission is the agency responsible for implementing the requirements of the Clean Air Act which gives authority for I/M programs. The ultimate decisions as to who will administer the program will be determined by factors such as the existence of a vehicle safety inspection program, the current structure of the governmental agencies, and the state legislature's ideas of the most workable arrangements.

### 3.5.3 Program Funding Sources

One of the most important factors in developing an inspection and maintenance program is securing adequate funding. Basically, the responsibility for funding of the program lies with the state and/or local agencies.

Funding is required for two purposes: (1) to provide capital to start the program, such as obtaining equipment, land and construction costs, and (2) to provide funds for operating and maintaining the program after it has started. The total amount of capital required depends upon the following factors: (1) the type of program (centralized vs. decentralized, state operated vs. privately operated); (2) the number of test lanes or inspection stations required; (3) the type of emission test (idle or loaded mode); and (4) whether the emission test is conducted as part of an existing vehicle safety inspection program.

The initial capital requirements can be acquired through several mechanisms such as issuing bonds or borrowing from the state treasury. An inspection fee can be charged to cover both the operating and maintenance costs and to help pay off any initial investment. Based on other I/M programs in operation in the United States, inspection costs range from $4 to $10, the latter figure most often associated with a safety inspection[11].

### 3.5.4 Enforcement Schemes and Consumer Protection

One of the factors involved in operating the program after it has started is to have an adequate system of enforcement in order to assure that each vehicle is inspected periodically. Most of the current programs

in operation require evidence of passing an emissions test prior to registration of a vehicle. This applies to both the yearly registration and whenever the ownership of the vehicle changes. Since experience in other state I/M programs has shown this system to be effective, it is also recommended for Louisiana's urban parishes. Evidence of compliance with an emission test can be demonstrated by a windshield sticker and a certificate of inspection, which can be issued on a staggered basis. Prior to implementation of the program, a decision will need to be made by the enforcement agency as to which vehicles may be exempted. For example, antique and classic cars are often exempted since they comprise only a small part of the vehicle population and usually are not used for commuting purposes. In order to have an effective I/M program, all vehicles whose owners reside in a parish which is going to implement I/M should be included in the inspection and maintenance program.

One of the more difficult problems in implementing an I/M program is in gaining public support. One of the main reasons for public concern is the fact that many individuals fear being abused by the system in the form of overcharges for repairs or unnecessary repairs. Care must also be taken to avoid hardships in terms of costly repairs, or the denial of vehicle registration without due cause. Again, certain classes of vehicles will need to be exempted, especially older cars owned by the segment of the population that can least afford expensive repairs to automobiles.

As an added measure, there needs to be a mechanism established to handle consumer complaints concerning overcharging and unnecessary repairs, and also complaints about the I/M program in general. A consumer affairs office or a group within the administering agency needs to be established for this purpose.

### 3.5.5 Operating Requirements

#### 3.5.5.1 Equipment Specifications

There are several manufacturers of automotive emission testing equipment and a wide range of testing equipment is currently available. Although the exact requirements of the equipment cannot be determined until an I/M option as well as a test procedure is selected, the equipment still

must meet basic specifications. The following are minimum specifications for hydrocarbon analyzers as recommended by several manufacturers and are being used in the New Jersey I/M program[16].

| | |
|---|---|
| Meter Range: | 0 - 500 ppm, low scale |
| | 0 - 2000 ppm, high scale |
| Accuracy: | ± 3% of full scale |
| Repeatability: | ± 2% of full scale |
| Ambient Temperature Range: | 35°F to 110°F |
| Ambient Humidity Range: | up to 95% |
| Response Time: | 90% of final reading within 10 seconds |
| Drift Stability: | ± 3% after 10 minute warmup |
| Calibration: | Provision for external gas source. |

In addition to these requirements, the analyzer should have a direct read-out for the pollutant so that both the inspector and vehicle owner can observe the results of the test.

3.5.5.2 Preventive Maintenance and Calibration

In compiling information for inspection and maintenance programs, six manufacturers were contacted to obtain equipment costs, specifications, and maintenance requirements. Each of the manufacturers can conduct a short training course in the operation, maintenance and calibration of the equipment. In addition, detailed operating and maintenance procedures are compiled in service documents for use by the equipment operators. Since the maintenance requirements vary for each instrument, they are not discussed in this document.

Calibration procedures also vary for each instrument; however, there are basic calibration procedures which must be adopted for use in all I/M programs. The instrument should be calibrated for the following cases: Whenever

1. A periodic check of the analyzer is required,
2. State inspection and/or certification is required,
3. Ambient temperature change of more than 40°F occurs,
4. Analyzer is relocated and/or involves a change in altitude of 1000 feet or more.

In calibration of the analyzers, the "zero" and "span" adjustments are vital. These should be performed only after the analyzer has warmed up to its specified operating temperature. These adjustments should be performed according to the manufacturer's instructions.

Periodic calibration of the analyzer against a known concentration of hydrocarbon gas is necessary. The calibration should be performed as often as necessary to maintain accuracy of the instrument. Records of calibration including the date, calibration gas standard, observed and/or corrected equipment reading and signature of the person performing the calibration should be documented.

3.5.5.3 Data Acquisition, Handling and Analysis

Once an inspection and maintenance program is in operation, it is essential that the program be monitored to determine its effectiveness. Although significant reductions in hydrocarbon emissions can be achieved by I/M, these reductions may not necessarily be evident in ambient air quality levels. Therefore, to determine the effectiveness of the program as well as the adequacy of operating and maintenance procedures, data must be collected at the inspection station. Sufficient data should be collected to allow determination of the rejection rate and the emission reductions achieved by the program.

Rejection Rate

The rejection rate can provide information that indicates whether operating procedures at all inspection stations are consistent. Too high or too low a rejection rate can mean that a station is not following proper testing procedures, the equipment is not functioning properly, or that vehicles tested at a certain station are above or below average emitters. If proper procedures are being followed and if the equipment is functioning within specifications, then a high or low rejection rate may be a function of the quality of maintenance being performed on the vehicles. This is especially true when vehicles are retested after a rejection.

If rejected vehicles are required to be retested before being allowed to operate, the number of times the vehicle returns for retest will indicate the quality of the corrective maintenance. If a high percentage

of rejected vehicles pass on the first retest, then this indicates that corrective maintenance is being properly diagnosed and performed. Regardless of whether the indication is that maintenance is good or poor, the administering agency should determine the cause, since the maintenance function is critical to the success of the program.

Determining the rate of rejection is relatively simple since the analyzers have a direct readout of the emissions. In addition, the analyzers can be equipped with either a buzzer or a lighting system which is triggered whenever the emissions exceed the standards. If data are being recorded on strip charts, then provisions can be made to automatically record the violations.

Emission Reduction

The reduction of motor vehicle emissions is a major indicator of whether an inspection and maintenance program is achieving its goals. The most accurate method of quantifying emission reduction is through the Federal test procedure, although adequate estimates can be obtained from the idle mode and loaded mode tests. The administering agency may wish to record, summarize and analyze the pollutant concentrations from each vehicle test, which would provide the most accurate results. Since this may be impractical for many agencies, a portion of the vehicle population can be sampled at various intervals to provide sufficiently accurate estimates of the emission reductions achieved. Proper statistical procedures should be used to determine the sample size and vehicle mix of the sample to assure that the sample is representative of the motor vehicle population being studied.

### 3.5.6 Quality Control

Among the problems associated with inspection and maintenance programs is that of quality control. This problem is more evident with decentralized facilities than with central stations. The two main quality control problems are nonuniformity of enforcement criteria and potentially inadequate data collection and handling. The first problem results in the stringency of the test from station to station, as often happens in safety inspections also. Some inspection personnel are less conscientious than others in maintaining test equipment in proper working order and also in conducting the emissions test.

Inadequate data collection eventually leads to difficulties in monitoring the success of the I/M program. Unless both accurate and precise emissions data are collected, adjustments in the program cannot be made since problems may go undetected.

Recognizing these potential problems, EPA requires that the following provisions be made to the I/M program in order to receive the emission reduction benefits:

1. Licensing of inspection facilities

The actual licensing requirements will be determined by the administering agency, although EPA guidelines recommend that each inspection facility have approved test equipment and employ someone competent in the operation of the equipment. The facility must agree to perform the specified recordkeeping and submit to inspections.

2. Recordkeeping

The records at each facility should include a description of each vehicle with its emission test results, plus information on the calibration of the test equipment. Copies of the records must be submitted to the administering agency periodically for review.

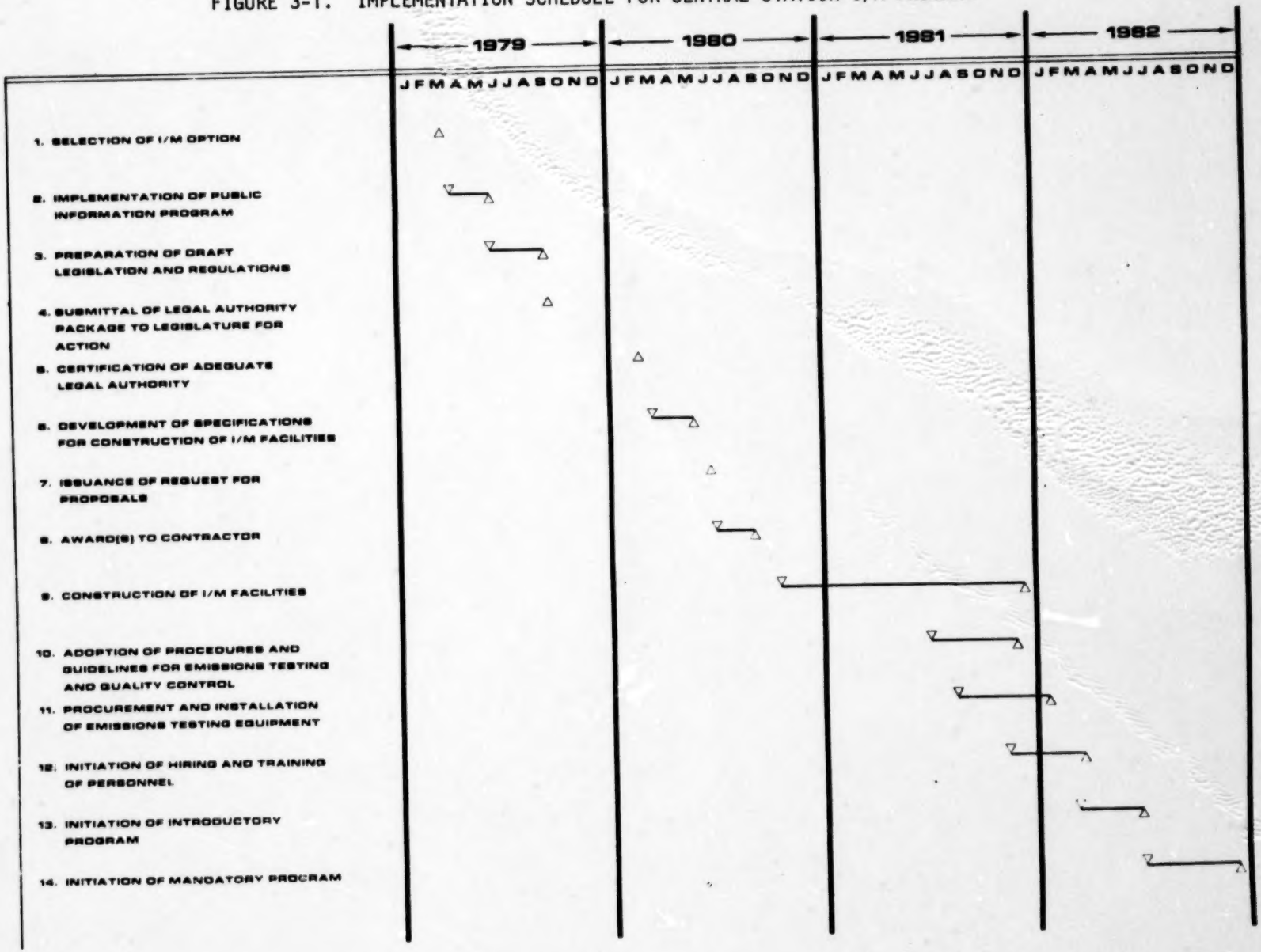
3. Monitoring of the inspection facilities

Each facility should be inspected at least once each 90 days to review operating, calibration, maintenance and recordkeeping procedures. In addition, EPA requires that the administering agency have a program of unannounced/unscheduled inspections to answer complaints and screen the operating procedures.

## 3.6 IMPLEMENTATION SCHEDULE

As previously mentioned, the 1977 Clean Air Act Amendments require a schedule for implementing an I/M program. Figure 3-1 shows the proposed schedule for central station facilities which, because of the long period required for construction of one or more facilities, would require a longer period of time for implementation than the inspection program at private garages.

FIGURE 3-1. IMPLEMENTATION SCHEDULE FOR CENTRAL STATION I/M PROGRAM


1979
1980
1981
1982
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1. SELECTION OF I/M OPTION
2. IMPLEMENTATION OF PUBLIC INFORMATION PROGRAM
3. PREPARATION OF DRAFT LEGISLATION AND REGULATIONS
4. SUBMITTAL OF LEGAL AUTHORITY PACKAGE TO LEGISLATURE FOR ACTION
5. CERTIFICATION OF ADEQUATE LEGAL AUTHORITY
6. DEVELOPMENT OF SPECIFICATIONS FOR CONSTRUCTION OF I/M FACILITIES
7. ISSUANCE OF REQUEST FOR PROPOSALS
8. AWARD(S) TO CONTRACTOR
9. CONSTRUCTION OF I/M FACILITIES
10. ADOPTION OF PROCEDURES AND GUIDELINES FOR EMISSIONS TESTING AND QUALITY CONTROL
11. PROCUREMENT AND INSTALLATION OF EMISSIONS TESTING EQUIPMENT
12. INITIATION OF HIRING AND TRAINING OF PERSONNEL
13. INITIATION OF INTRODUCTORY PROGRAM
14. INITIATION OF MANDATORY PROGRAM

# APPENDIX A
# DESCRIPTION OF LOADED MODE TEST PROCEDURES

## FEDERAL THREE MODE TEST

1. Car accelerated to 50 mph; it is then run at 50 mph under different road load conditions according to vehicle weight. Manual transmission cars are run in high gear.

| Car Weight (lbs.) | Road Load (Horsepower) |
|---|---|
| <2500 | 21 |
| 2500 -- 3500 | 26 |
| 3500 -- 4500 | 31 |
| >4500 | 36 |

2. Car is run at 30 mph, manual transmission is in high gear.

| Car Weight (lbs.) | Road Load (Horsepower) |
|---|---|
| <2500 | 9 |
| 2500 -- 3500 | 12 |
| 3500 -- 4500 | 15 |
| >4500 | 18 |

3. Idle mode: Car is run at idle according to manufacturer's specifications. Vehicle is in neutral gear for both manual and automatic transmissions.

## CLAYTON KEY MODE

| Class of Vehicle By Weight (lbs.) | Transmission Range/Gear | High Speed MPH | High Speed Dyno Load(HP) | Low Speed MPH | Low Speed Dyno Load(HP) | Idle |
|---|---|---|---|---|---|---|
| 2000 -- 2750 | Lower gear (3rd.) | 36-38 | 15 | 22-25 | 10 | Automatic Transmission |
| 2800 -- 3750 | Drive or high gear | 44-46 | 24 | 29-32 | 16 | In Drive |
| 3800 -- up | Drive or high gear | 48-50 | 30 | 32-35 | 21 | |

## NEW JERSEY/NEW YORK COMPOSITE TEST

| Mode | Time in Mode (Seconds) |
|---|---|
| 1. Idle | 22 |
| 2. 0 to 30 mph acceleration | 15 |
| 3. 30 mph cruise | 15 |
| 4. 30 to 10 mph deceleration | 12 |
| 5. 10 mph cruise | 7 |
| 6. 10 to 0 mph deceleration | 4 |
| | 75 |

## FEDERAL SHORT CYCLE

| Transition | MPH | Time (seconds) |
|---|---|---|
| 1. Acceleration | 0 to 60 | 6 |
| 2. Deceleration | 60 to 29 | 23 |
| 3. Constant speed | 29 | 10 |
| 4. Acceleration | 29 to 37 | 18 |
| 5. Acceleration | 37 to 42 | 4.5 |
| 6. Deceleration | 42 to 37 | 2.5 |
| 7. Deceleration | 37 to 20 | 32 |
| 8. Deceleration | 20 to 0 | 7.5 |
| 9. Constant (automatic in drive) | Idle | 21.5 |
| | | 125.0 |

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